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OBLIQUE VENEER LAMINATED MATERIAL AND METHOD OF MANUFACTURING THE SAME

FIELD OF THE INVENTION

The present invention relates to laminated veneer lumber of diagonal type in which veneer sheets are glued or laminated together with the wood grain thereof oriented diagonally or obliquely with respect the lateral sides of the lumber (such laminated veneer lumber may be referred to as "diagonal LVL"). The invention relates also to a method of manufacturing such diagonal laminated veneer lumber.

BACKGROUND OF THE INVENTION

As the wood board which is made by laminating veneer sheets by adhesive, glued laminated wood such as laminated lumber, plywood having veneer sheets laminated together such that any two adjacent veneer sheets are arranged with the wood grain thereof oriented perpendicularly to each other, laminated veneer lumber (LVL) in which constituent veneer sheets are laminated together with the wood grain thereof extending parallel to each other, etc. have been known in the art.

General demand for the wood board or panel is changing from plywood to a wood board such as oriented strand board (OSB), which is also referred to as waferboard. A reason for such increasing demand for OSB is that the constituent element of OSB is not veneer, but smaller pieces of wood called strands which are arranged with the wood grain thereof discrete or interrupted, and its greater in-plane shear strength as compared with plywood.

FIG. 7(A) schematically shows plywood in which one of two adjacent veneer sheets thereof has its wood grain extending substantially parallel to one side of the plywood board and the other of the two adjacent veneer sheets has its wood grain extending substantially perpendicular to the above one side of the plywood board, while FIG. 7(B) shows plywood of another type in which two adjacent veneer sheets thereof have their wood grain extending diagonally in opposite directions at about 45° so that the wood grain of the two veneer sheets are oriented perpendicularly to each other (straight and dotted lines in the square frame represent the wood grain directions

of the two adjacent veneer sheets, respectively). FIG. 7(C) shows particleboard (PB). Values provided below the square frames in FIG. 7 represent the shear strengths of the respective board materials.

It has been known in the art that plywood which is made by clipping veneer sheets and arranging such clipped veneer sheets with the grain thereof oriented diagonally at about 45° with respect to the ends or lateral sides of the plywood board, as shown in FIG. 7(B), has a shearing strength that is greater than that of particleboard. As shown in FIG. 6, it has been also known that the shear modulus becomes the greatest when the veneer sheets are arranged with the wood grain thereof oriented diagonally at about 45° with respect to shear plane. It has been known in the art, therefore, that veneer sheets may be cut and arranged as shown in FIG. 7(B) to overcome drawbacks of conventional plywood.

Since it is considered that particleboard (PB) shown in FIGS. 6 and 7 has substantially the same elements orientation as the aforementioned OSB, the strength of particleboard is substantially the same as that of OSB.

However, no such plywood is seen in actual market that is strengthened as described above. A decisive reason for such disuse is that cutting the existing plywood boards for production of the above plywood board will waste substantially half of the material. Thus, even the possibility of the presence of plywood or veneer laminated board of the above-described structure has been very little considered. If the veneer laminated board which overcomes the drawbacks of conventional plywood by having its constituent veneer sheets arranged and laminated together with the grain thereof oriented diagonally at about 45° with respect to the ends or lateral sides of the resulting board is reasonably manufacturable, demand for such board having outstanding characteristics and performance will be created and the provision of such board will be desired by the market.

As shown in the Publication of Laid-open Japanese Patent Application, No. H9-248803, it has been known in the art that a plywood board may be reinforced by providing between any two adjacent veneer sheets of the plywood board an additional veneer sheet whose wood grain are oriented at about 45°, or an angle between 20° and

70°, with respect to the ends or lateral sides of the plywood board.

However, according to this method in which ordinary rotary-cut veneer sheets are clipped diagonally into lozenged or diamond-like shaped veneer sheets, each lozenged veneer sheet is further clipped into a smaller-sized rectangular veneer sheet by cutting off triangular end portions and such rectangular veneer sheet is laminated between any two veneer sheets in the plywood. However, this method of manufacturing plywood is disadvantageous in terms of labor cost and material cost.

In view of the aforementioned problems, a primary object of the present invention is to provide a laminated veneer lumber having a high strength which is achievable by laminating veneer sheets with the wood grain thereof oriented diagonally with respect to the lateral sides of the lumber. It is also an object of the present invention to provide a method of manufacturing such laminated veneer lumber which permits mass production thereof with low cost and little waste by using existing conventional production line including veneer peeling machine and veneer clipping machine.

The present invention intends to achieve the following derivative effects.

(1) Though presently no wood board having an in-plane shear strength corresponding to that of OSB is manufactured, the invention achieves providing diagonal laminated veneer lumber whose strength is greater than that of OSB.

(2) The invention makes it possible to manufacture various kinds of wood products with high performance such as horizontal members or beams and structural wall board by processing the above diagonal laminated veneer lumber.

(3) One of typical applications where OSB is used in large quantities in North America is the web for I-beam (also called as I-joist). The diagonal laminated veneer lumber of the invention has an in-plane shear strength that is greater than that of OSB. Therefore, the present invention is directed to provide high-performance I-beam made of the diagonal laminated veneer lumber as an OSB replacement.

(4) As described above, using the diagonal laminated veneer lumber of the present invention, horizontal structural member with high strength can be made. Thus, the use of such material makes it possible to design a long-spanned architecture with a

higher degree of freedom, and the quantities of wall, beam and pillar members for use and hence the total cost for such architecture can be reduced.

(5) Cedar that is one of the typical species of wood in Japan has a high strength for its lightweightness and such characteristics of cedar can be enhanced to the greatest extent by the present invention. Thus, the invention can contribute to promoting the demand of cedar. Additionally, the present invention can serve to promote the effective utilization of wood available from thinning forest.

DISCLOSURE OF THE INVENTION

In order to solve the above problem, the present invention provides diagonal laminated veneer lumber having veneer sheets laminated together with the wood grain thereof oriented diagonally with respect the lateral sides. In the first place, the diagonal laminated veneer lumber 2 having a plurality of layers of veneer 2a which are laid one on another and laminated together by adhesive into the form of a board or a column is characterized in that each of the layers of veneer 2a has a plurality of clipped small sheets of veneer 1a which are arranged successively in the longitudinal direction with two adjacent sides of any two adjacent such small veneer sheets 1a set in abutment with each other thereby to from the layer of veneer 2a, and a plurality of the layers of veneer 2a are laminated together such that any two adjacent layers of veneer 2a are disposed with the wood grain *a* thereof oriented in opposite directions diagonally with respect to the lateral sides of the layer of veneer 2a.

In the second place, the diagonal laminated veneer lumber 2 is characterized in that the wood grain *a* of the clipped small sheets of veneer 1a is oriented so as to intersect the clipped sides *c* of the clipped small sheets of veneer 1a.

In the third place, the diagonal laminated veneer lumber 2 is characterized in that the wood grain *a* of the clipped small sheets of veneer 1a is oriented substantially in the same direction as the clipped sides *c* of the clipped small sheets of veneer 1a.

In the fourth place, the diagonal laminated veneer lumber 2 is characterized in that the layers of veneer 2a are disposed with the wood grain *a* thereof oriented diagonally at an angle between 30° to 60° with respect to the lateral sides of the layer of veneer 2a.

In the fifth place, the diagonal laminated veneer lumber 2 is characterized in that the layers of veneer 2a are laminated together spirally such that laminated veneer wood in the form of a circular or cylindrical column having a straight axis is formed.

In the sixth place, the present invention provides a method of manufacturing diagonal laminated veneer lumber 2 having a plurality of layers of veneer 2a which are laid one on another and laminated together by adhesive into the form of a board or a column, which is characterized by providing the layer of veneer 2a by arranging and joining successively a plurality of clipped small sheets of veneer 1a with two adjacent sides of any two adjacent such small veneer sheets 1a set in abutment with each other such that the wood grain *a* thereof is oriented diagonally with respect to the lateral side of the layer of veneer 2a, and laminating a plurality of the layers of veneer 2a one on another such that any two adjacent layers of veneer 2a are disposed with the wood grain *a* thereof oriented in opposite directions diagonally with respect to the lateral side of the layer of veneer 2a.

In the seventh place, the method of manufacturing diagonal laminated veneer lumber 2 is characterized in that the small veneer sheets 1a are made by clipping a rotary-cut veneer sheet having its wood grain *a* oriented perpendicularly to the longitudinal ends of the rotary-cut veneer sheet along cutting lines *c* extending diagonally with respect to the wood grain *a*.

In the eighth place, the method of manufacturing diagonal laminated veneer lumber 2 is characterized in that the small veneer sheets 1a are made by clipping a rotary-cut veneer sheet along cutting lines *c* extending diagonally with respect to the wood grain *a* of the veneer.

In the ninth place, the method of manufacturing diagonal laminated veneer lumber 2 is characterized in that the small veneer sheets 1a are made by clipping a sliced veneer sheet along cutting lines *c* extending diagonally with respect to the wood grain *a* of the veneer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1(A) and 1(B) are plan views showing steps of a first embodiment of the methods of manufacturing diagonal laminated veneer lumber according to the

present invention, including clipping a veneer sheet and of gluing or laminating the clipped veneer sheets.

FIGS. 2(A), 2(B) and 2(C) are plan views showing steps of a second embodiment of the method of manufacturing diagonal laminated veneer lumber according to the present invention, including clipping of a veneer sheet and arranging or joining the clipped small veneer sheets into a band of veneer and laminated layers of veneer into diagonal laminated veneer lumber.

FIGS. 3(A) and 3(B) are plan views similar to FIGS. 1(A) and 1(B), but showing an embodiment of the present invention wherein the veneer sheet to be clipped diagonally is a sliced veneer sheet.

FIG. 4 is a partial perspective view showing the structure of an I-beam as a test piece used for comparison of strength of I-beams made of the diagonal laminated veneer lumber made according to present invention and other wood boards.

FIG. 5 is a graph showing the test results or load-deflection curves of three different test pieces of FIG. 4.

FIG. 6 is a graph showing variation of shear modulus depending on the orientation angle of the wood grain of plywood in comparison with other wood materials.

FIGS. 7(A), 7(B) and 7(C) show two different kinds of plywood having different wood grain orientations and a particleboard (PB) together with the shear strengths thereof.

PREFERRED EMBODIMENT OF THE INVENTION

Referring to FIGS. 1(A) and 1(B) showing a first embodiment of the present invention, the drawings illustrate steps of clipping a band of veneer sheet 1 which has been rotary-cut, for example, by a rotary lathe and then laminating clipped small veneer sheets 1a together.

As is well known in the art, the rotary-cut veneer sheet 1 has a longitudinal dimension as measured along the wood grain which oriented substantially perpendicularly to the opposite longitudinal ends *b* of the veneer sheet 1 as indicated by symbol *a*. The band of veneer sheet 1 is clipped along cutting lines *c* extending

diagonally at an angle in either direction with respect to the longitudinal ends *b* (or at about 45° downwardly leftward as seen in the plan view in the illustrated example) into a plurality of substantially lozenge-shaped small veneer sheets 1a, as shown in FIG. 1(A).

The lozenge-shaped veneer sheet 1 may have any thickness depending on the application or usage of the final board product, ranging, for example, 1.00 mm to 6.5 mm, and the species or quality of the veneer sheet 1 is not particularly specified as far as the veneer sheet is strong enough and suitable for manufacturing of plywood or any other similar veneer laminated wood. Clipping of the veneer sheet 1 may be done by any suitable veneer clipping machine (not shown) of the type which is generally used in the art.

FIG. 1(B) shows a step of arranging or joining the clipped lozenge-shaped veneer sheets 1a into a continuous layer of veneer 2a and then laminating a plurality of such layers of veneer 2a thereby to make a board of diagonal laminated veneer lumber 2 in the form that is similar to plywood. It is noted that for the sake of clear understanding of the manner of veneer lamination and structure thereof, the layers of veneer 2a are shown staggered vertically and part of the top layer is cut off to show the relationship between any two adjacent layers of veneer 2a in the diagonal laminated veneer lumber 2.

In the example shown in FIG. 1(B), the lozenge-shaped small veneer sheets 1a are laid or arranged successively with two adjacent sides of any two adjacent lozenged veneer sheets 1a set in abutment with each other such that the wood grain of the small veneer sheets 1a of each veneer layer 2a is oriented in the same direction that is diagonal to the lateral side *c* (or the clipped side of veneer sheet 1a), thereby forming a layer of veneer 2a. Then, a plurality of such layers of veneer 2a are laminated together so that the wood grain thereof is oriented diagonally at an angle (about 45° in the illustrated example) with respect to the lateral sides of the resulting board 2 as indicated by the wood grain direction *a*. It is noted that the lozenge-shaped small veneer sheets 1a may be joined by glue at the longitudinal ends *b* thereof for forming the layer of veneer 2a.

In the illustrated example, the wood grain *a* of any two adjacent layers of veneer 2a disposed one on the other is oriented in opposite diagonal directions so that the wood grain directions *a* of the two adjacent veneer sheet layers 2a intersect at about 90°.

Arranging layers of veneer 2a in a stack with the wood grain thereof oriented in alternately opposite diagonal directions and with adhesive interposed between any two adjacent layers of veneer 2a, and then gluing the stack of veneer layers 2a under a pressure (while applying heat as required) in a conventional known manner, a board of diagonal laminated veneer lumber 2 is produced in which the veneer layers 2a are disposed in the resulting board 2 such that the wood grain thereof are oriented at about 45° with respect to the lateral sides of the board 2 and also that the wood grain of any two adjacent veneer layers 2a are oriented so as to intersect at about 90°.

It is noted that for the sake of description each layer of veneer 2a shown in FIG. 1(B) has at opposite ends thereof triangular portions having an acute angle of about 45°, but such triangular corner portions will be cut off after the diagonal laminated veneer lumber 2 has been completed. Alternatively, such triangular portions may be removed from the layers of veneer 2a before they are arranged in a stack for lamination. The same holds true of the other embodiments of the present invention.

Reference is made to FIGS. 2(A) through 2(C) which show a second embodiment of the present invention. In the following description, some like elements are designated by like reference numeral or symbols. A rotary-cut veneer sheet 1 is clipped along cutting lines *c* extending substantially in the same direction as the wood grain *a* of the veneer sheet 1 (i.e. the direction extending perpendicularly to the opposite longitudinal ends *b* of the veneer sheet 1) into a plurality of small veneer sheets 1a of a substantially square or rectangular shape. Subsequently, a number of thus clipped small veneer sheets 1a are arranged or joined successively with any two adjacent non-clipped sides (longitudinal ends *b*) of any two adjacent veneer sheets 1a set in abutment with each other as shown in FIG. 2(B) thereby to form a band of veneer 1' whose wood grain are oriented generally along the lateral sides *c* (or the

previous cutting lines in FIG. 2(A)).

As shown in FIG. 2(B), the band of veneer 1' is clipped along cutting lines *c'* extending diagonally at about 45° with respect to the lateral sides *c* of the band of veneer 1' (hence extending diagonally at the same angle of about 45° with respect to the wood grain direction *a*) into a plurality of veneer sheets 1'a of a lozenge or parallelogram shape.

Then referring to FIG. 2(C), the parallelogram-shape veneer sheets 1'a are joined one after another at the sides thereof corresponding to the previous cutting lines *c* into a plurality of layers of veneer 2'a and such layers of veneer 2'a are arranged and laminated together in the same manner as described with reference to FIG. 1(B), thus a board of diagonal laminated veneer lumber 2 according to the present invention being formed. Triangular corner portions, as referred to previously in FIG. 1(B), will be cut off after the diagonal laminated veneer lumber 2 has been completed.

Referring to FIGS. 3(A) and 3(B) showing still another embodiment of the present invention, a band of veneer sheet 1 which is to be clipped into a plurality of small veneer sheets 1a is a sliced sheet of veneer having its wood grain oriented in the longitudinal direction thereof as indicated by symbol *a*.

In this embodiment, the sliced veneer sheet 1 is clipped along cutting lines *c* extending diagonally at about 45° with respect to the lateral sides *b* of the sliced veneer sheet 1 into a plurality of substantially parallelogram-shaped small veneer sheets 1a. Such veneer sheets 1a are joined together successively at their non-clipped lateral sides *b*, thereby providing a plurality of layers of veneer 2a. Such layers of veneer 2a are laminated together in the same manner as described with reference to FIGS. 1(B) and 2(C) for forming a board of diagonal laminated veneer lumber 2.

In either of the above-described embodiments, rotary-cut or sliced veneer sheet is clipped into small veneer sheets 1a and such clipped veneer sheets 1a are joined one another thereby to form a layer of veneer 2a. It is noted, however, that such layer of veneer 2a can be made by slicing veneer from a wood block which is formed by bonding together wood strips (or a flitch).

FIG. 4 shows an I-beam 3 used as a test piece for comparison of the strength

of various I-beams made of the diagonal laminated veneer lumber 2 made according to the method described with reference to FIG. 1, conventional OSB and plywood. The I-beam 3 has the following dimensions:

Board thickness (t) = 9 mm

Top width (W) including web = 49 mm

Web height (h) = 26 mm

Total height (H) = 150 mm

The results of three-point bending test of respective I-beams 3 made of three different wood materials are shown by the load-deflection curves in the graph of FIG. 4. As apparent from the graph, it has been found from the test that the diagonal LVL of the present invention showed smaller deflection against the application of load as compared with plywood and OSB.

TABLE 1 below shows comparison of the strengths of the I-beams 3 of three different materials, wherein values for the plywood are set at 100 as reference value. TABLE 1 has also clarified that the diagonal LVL of the present invention is superior in strengths to plywood and OSB.

	Diagonal LVL	OSB	Plywood
Bending strength	145	122	100
Proportional limit of bending	154	130	100
Young's modulus	168	165	100

As is apparent from FIGS. 6 and 7, the strength of the diagonal laminated veneer lumber 2 becomes the greatest when the constituent veneer sheets are arranged with the wood grain thereof oriented diagonally at about 45° with respect to the longitudinal ends or lateral sides of the board. It is noted, however, that the board having the wood grain thereof oriented at a diagonal angle between 30° and 45° has a strength which substantially corresponds to that of OSB and, therefore, it can be used for practical applications. It is also noted that the layers of veneer 2'a for lamination need not have the wood grain thereof oriented in opposite directions alternately, but any layer of veneer whose wood grain is oriented perpendicular or parallel to the

lateral sides of the board may be interposed between any two adjacent layers of veneer 2'a. It is further noted that, although the wood grain direction *a* is indicated by a single-head arrow directing in one direction, but it may be directed in the opposite direction.

Though the foregoing description has dealt with the embodiments of diagonal laminated veneer lumber in the form of a board, laminated veneer wood in the form of a column having a rectangular or polygonal cross-section may be made by laminating the layers of veneer.

Additionally, laminated veneer wood in the form of a circular or cylindrical column or a beam may be made by laminating the layers of veneer spirally about the straight axis of the column or the beam.

INDUSTRIAL UTILIZATION OF THE INVENTION

The laminated veneer lumber of the present invention can be widely utilized for structural material for building such as board, beam and column.

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